State of South Carolina's Coastal Resources

Coastal Habitat Condition

The Resource

South Carolina's extensive estuarine and coastal waters represent an extremely valuable state resource that must be protected to ensure both the viability of the state's commercial and recreational fishery resources as well as the general health of these ecosystems for recreational use and quality of life. Estimates on the economic impact of the state's saltwater recreational and commercial fisheries exceeds 650 million dollars, and almost all of the species harvested utilize estuaries for some portion of their life cycle. Population growth in South Carolina has been considerable, with an increase of more than 500,000 people living in the state from 1990 to 2000. The construction of infrastructure (e.g., roads, commercial development, residential housing, industry) that accompanies human development will alter the rate and volume of freshwater inflow as well as the type and amount of pollutants introduced into estuaries. Therefore, increased coastal growth has a high potential to seriously impact South Carolina's coastal environment.

The South Carolina Estuarine and Coastal Assessment Program (SCECAP) was initiated in 1999 as a collaborative program between the South Carolina Department of Natural Resources (SCDNR) and the South Carolina Department of Health and Environmental Control (SCDHEC). The goal of SCECAP is to monitor the condition of the state's estuarine habitats to determine the proportion of the coastal zone that meets desired criteria with respect to water quality, sediment quality, and biotic condition. SCECAP supplements and compliments numerous ongoing monitoring programs being conducted by the SCDNR and SCDHEC in our coastal habitats and provides a more comprehensive assessment of the overall health of these habitats that may change with increasing coastal development. Other cooperating agencies include the U.S. Environmental Protection Agency, the National Oceanic and Atmospheric Administration Center for Coastal Environmental Health and Biomolecular Research, the U.S. Fish and Wildlife Service, and SCDHEC's Office of Ocean and Coastal Resource Management.

Methods

Approximately 60 stations are randomly selected for sampling each year. All sites are located within the coastal zone extending from the saltwater – freshwater interface to near the mouth of each estuarine drainage basin and extending from Little River Inlet at the North Carolina border to the Wright River near the Georgia border (Figure 1). The Savannah River is not included in the SCECAP initiative, but is being sampled by the Georgia Coastal Resources Division as part of the USEPA National Coastal Assessment Program.

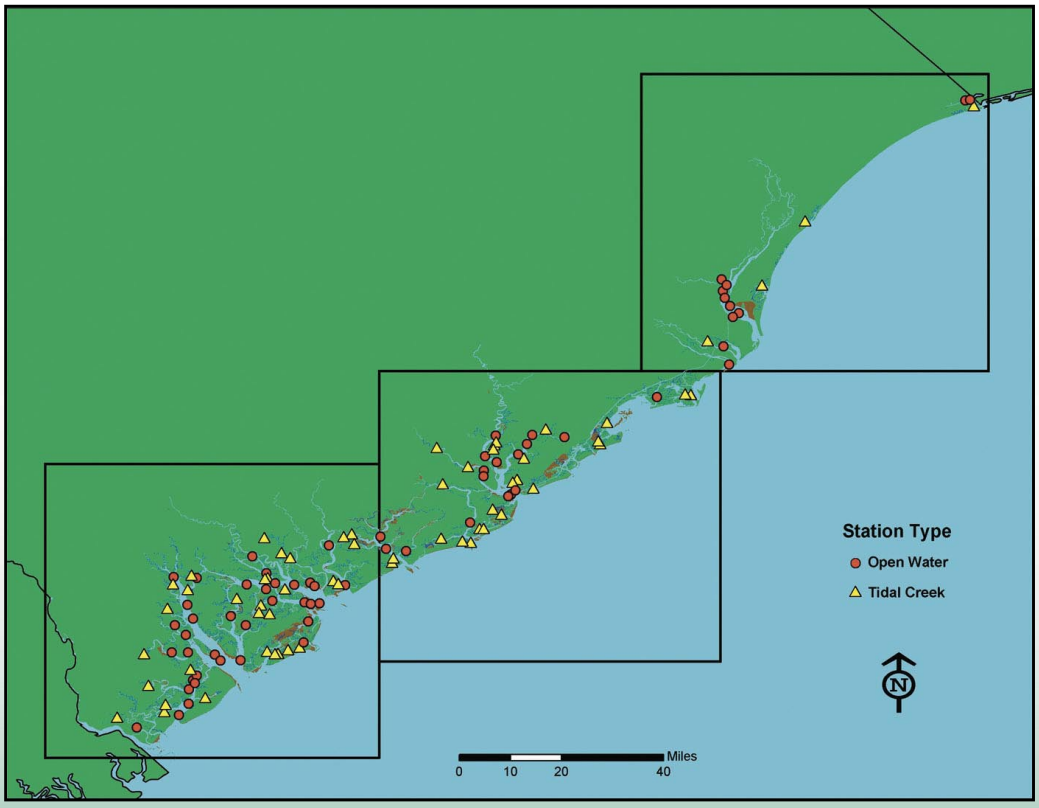


Figure 1. Distribution of open water and tidal creek stations sampled throughout South Carolina's coastal zone during 2001-2002. Brown respresents shallow areas that cannot be sampled using SCECAP protocols, and dark blue represents area designated as tidal creek habitat.

Approximately half of the stations are located in tidal creek habitats, with the remaining stations located in larger open water bodies that form South Carolina's tidal rivers, bays, and sounds. For the purposes of SCECAP, tidal creeks are defined as estuarine water bodies less than 100 m (328 ft) in width from marsh bank to marsh bank. All stations are sampled once during the summer months (mid June through August) for all variables. The summer period was selected because it represents a period when some water quality variables may be most limiting and it is the season when many fish and crustacean species of concern are utilizing estuaries as nursery habitat. Additional monthly sampling is conducted by SCDHEC staff who collect water quality samples during the remainder of the year.

A wide variety of water quality, sediment quality, and biological measurements are collected at each site. The primary water quality measurements are: dissolved oxygen, chlorophyll-a, nutrients (nitrogen and phosphorus), fecal coliform bacteria, and pH levels. Other important variables, such as temperature, salinity, total organic carbon, and turbidity are also included in our assessments of water quality. Some measurements include both instantaneous and time series data.

Bottom sediment samples are collected at every site to provide information on the composition (amount of sand versus mud), contaminant levels (15 metals, 25 polycyclic aromatic hydrocarbons (PAHs), 30 polychlorinated biphenyls (PCBs), and 23 pesticides), and toxicity using multiple sediment bioassay tests.

Biological samples are also collected to evaluate the condition of bottom dwelling invertebrates living in the sediments, and to evaluate the composition and abundance of fish and crustaceans (primarily penaeid shrimp and blue crabs) present. Fish tissue samples are obtained for contaminant analyses. Species targeted include silver perch, spot, Atlantic croaker, and weakfish.

Findings

The following sections summarize results obtained from the most recent survey period that has been fully completed with respect to all sample analyses (2001-2002). The 2003-2004 samples are still being processed and analyzed. Two-year data sets are used to provide a sufficient number of stations sampled for each habitat type with good statistical confidence. Evaluation of annual trends over the first four years of the program are also provided for the integrated measures of water quality, sediment quality, and habitat condition using both tidal creek and open water habitats combined.

Water Quality

Dissolved oxygen is one of the most critical water quality parameters measured in this program. Low dissolved oxygen conditions can limit the distribution or survival of most estuarine biota, especially if these conditions persist for extended time periods. The primary measure of dissolved oxygen used for SCECAP is based on a 25-hr average of measurements collected every 15 minutes by water quality meters deployed in the bottom waters at each site. During 2001 and 2002, approximately 89% of the state's open water habitat had good to very good DO levels, which should not be limiting to most species of concern. Only 8% of the open water habitat had fair DO conditions, and 3% of the open water sites had poor DO concentrations. In contrast, 78% of the state's tidal creek habitat had good to very good DO conditions, 13% of this habitat had fair DO concentrations, and 9% had poor DO concentrations that may be limiting to species.

Measures of pH provide another indicator of water quality in estuarine habitats. Because pH measurements are based on a logarithmic scale, even small changes in the value can result in significant stress to estuarine organisms. Low pH values can also indicate the presence of pollutants. The average pH observed in 2001-2002 in both tidal creeks and open water habitats indicated good conditions at most sites. However, a higher percentage of the state's creek habitat had pH values considered to be fair or poor (17% collectively) compared to the state's open water habitat (5% fair, no poor pH levels).

Nutrient loading into estuarine waters has become a major concern due to the rapid development that is occurring in the coastal zone of South Carolina and other states. This development results in increased nutrient input from wastewater treatment facilities, some industrial facilities, urban and suburban runoff of fertilizers, vehicle exhaust, etc. Other sources of nutrients include runoff from agricultural areas, riverine input, and atmospheric deposition. High nutrient levels can lead to enrichment or eutrophication of estuarine waters resulting in excessive algal growth, including harmful algae blooms, decreased dissolved oxygen levels, and other undesirable effects that adversely affect estuarine biota. Only about 3% of the state's creek habitat and 4% of the state's open water habitat had elevated total nitrogen concentrations considered to be moderately enriched, and $\leq$ 1% of either habitat had high nitrogen values considered to be highly enriched. The majority of the state's waters also had good phosphorus levels. Only 15% of the state's creek habitat and 12% of the state's open water habitat had moderately enriched total phosphorus levels. An additional 5% of the state's creek habitat and 1% of the state's open

water habitat had total phosphorus concentrations that were considered to highly enriched.

Phytoplankton in the water column is based on chlorophyll-a concentrations. High chlorophyll-a concentrations provide an indication of possible estuarine eutrophication since phytoplankton responds rapidly to enriched nutrient concentrations. Only 1% of the state's open water habitat and 7% of the state's tidal creek habitat had elevated chlorophyll-a concentrations considered to be poor. The slightly higher chlorophyll concentrations in tidal creeks may be reflective of the higher nutrient concentrations observed in the creeks. It may also reflect possible re-suspension of benthic algae from the creek bottoms and nearby marsh surfaces.

Coliform bacteria are present in the digestive tracts and feces of all warm-blooded animals. Public health studies have established correlations between adverse human health effects and concentrations of fecal coliform bacteria in recreational, drinking, and shellfish harvesting waters. Approximately 73% of the state's creek habitats had low coliform levels, 24% had moderately high levels, and 3% had coliform concentrations considered to be very high. Approximately 83% of the state's open habitat had low fecal coliform levels, with 17% having moderately high fecal coliform concentrations, and no sites having very high levels. The higher fecal coliform counts observed in creek habitats is most likely due to the proximity of these small drainage systems to upland runoff from both human and domestic wastes as well as wildlife sources, combined with the lower dilution capacity of creeks compared to larger water bodies. Greater protection of tidal creek habitats is warranted in areas where upland sources of waste can be identified and controlled.

Integrated water quality scores were calculated for each station based on the six water quality measurements summarized in this report. Results of the 2001-2002 survey indicted that approximately 73% of the state's creek habitat during this survey period was good, 22% had fair water quality, and 5% of the creek habitat had poor water quality (Figure 2). In contrast, 88% of the state's open water habitat had good water quality overall, 12% was considered to be fair in quality, and none of the open water habitat sampled in this survey period had poor water quality.

Comparison of the state's overall water quality condition on an annual basis indicates very little change over the four-year period (Figure 3). While the SCECAP sampling approach is not as suitable for trend analysis compared to fixed stations, it is possible to report changes in condition over time using this approach. For all four years, more than 80% of the state's estuarine waters (tidal creek and open

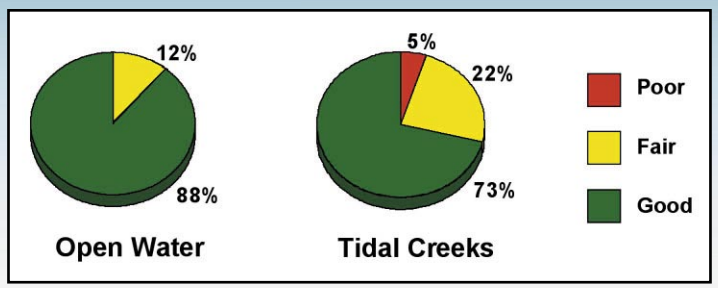


Figure 2. Proportion of the South Carolina's estuarine habitat that ranks as good (green), fair (yellow) or poor (red) using the integrated water quality score developed for the SCECAP program.

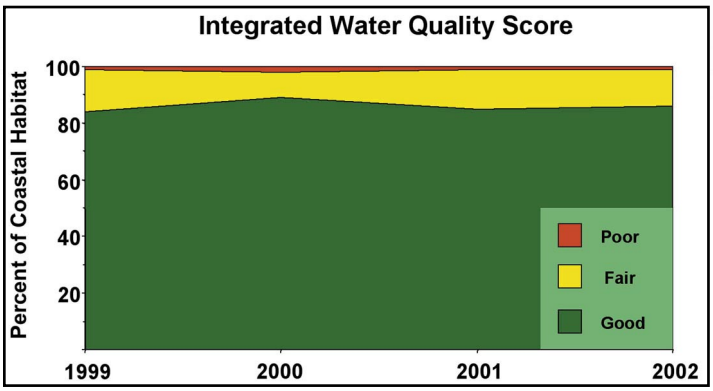


Figure 3. Proportion of the South Carolina's estuarine habitat that ranks as good (green), fair (yellow) or poor (red) using the integrated water quality score when tidal creek and open water habitats are combined and compared on an annual basis.

water habitat combined) rank as good in quality using the SCECAP criteria, and less than 5% of the estuarine waters are considered to be poor in quality in any given year. The lack of any major change in condition over time is probably due in part to the fact that all sampling has occurred during a major and unusual drought period. Return of climatic conditions to conditions with higher rainfall, resulting in more upland runoff, may change the water quality estimates considerably. The 2003-2004 survey should be indicative of estuarine water quality conditions during years with more normal rainfall.

Sediment Quality

While individual contaminants can be elevated at some sites, a better assessment of overall pollution exposure can be derived from the combined concentrations of 24 contaminants present at a site that have published bioeffects guidelines. Approximately 24% of the tidal creek habitat assessed in 2001-2002 had contaminant concentrations indicative of a moderate risk to bottom-dwelling communities. In comparison, 17% of the open water habitat had

similar concentrations, and an additional 3% had contaminant concentrations indicative of a high risk to bottom-dwellingcommunities.

Even if estuarine sediments have high contaminant levels, the contaminants may not be available to biota living in the sediments. Laboratory bioassays are used as indicators of both contaminant bioavailability and potential for toxicity. Approximately 18% of the state's creek habitat and open water habitat had sediment considered to be toxic, with an additional 55% and 35%, respectively, showing some evidence of toxicity.

The integrated sediment quality index combines measures of sediment contaminant concentrations and sediment toxicity. For 2001-2002, none of the tidal creek habitat had poor overall sediment quality and 40% had fair overall quality (Figure 4). For open water habitats, 2% of the habitat was considered to have poor overall quality, and 28% had fair sediment quality.

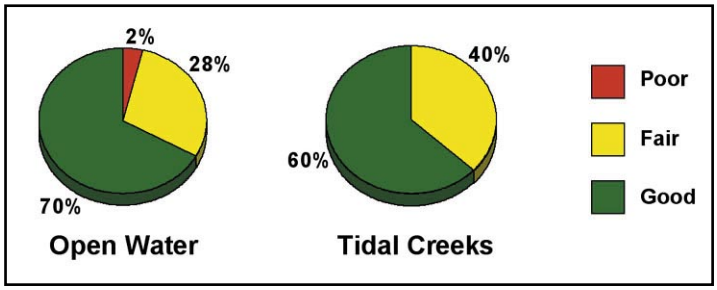


Figure 4. The proportion of the South Carolina's estuarine habitat that ranks as good (green), fair (yellow), or poor (red), using the integrated sediment quality score developed for SCECAP. This measure of overall sediment quality incorporates the concentration of 24 contaminants relative to known bioeffects levels, and the number of bioassays showing toxicity.

Annual comparisons show an increasing area of estuarine habitat that was considered poor or fair from 1999 to 2002 (Figure 5). The 1999 evaluation showed that none of the estuarine habitat was considered poor and 15% of the habitat was fair. The 2002 evaluation shows 3% of the estuarine habitat was poor and 27% was fair, an overall increase of 15% of the habitat falling into the poor or fair categories.

Biological Condition

Bottom-dwelling invertebrates are important because they are near the bottom of the food chain and are common food items for many fish and crustacean species. They are also considered to be excellent indicators of environmental stress because they are sessile and cannot easily avoid exposure to natural or anthropogenic stresses. Finfish and

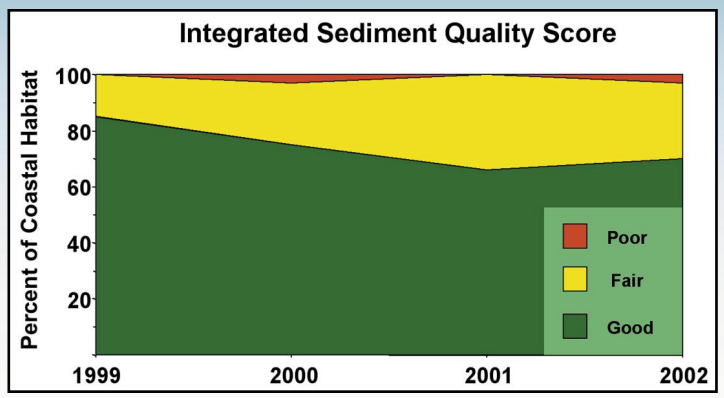


Figure 5. Proportion of the South Carolina's estuarine habitat that ranks as good (green), fair (yellow) or poor (red) using the integrated sediment quality score when tidal creek and open water habitats are combined and compared on an annual basis.

crustacean species are assessed because they utilize estuarine waters for food, refuge from predators, and as valuable habitats for egg, larval, juvenile, and adult life stages. Currently, the SCECAP program uses a benthic index of biological integrity (B-IBI) as the primary measure of biotic condition. SCECAP will continue to collect data on finfish and crustacean communities, but for the present time the program will rely solely on the B-IBI to evaluate the biological condition of South Carolina's estuarine habitats.

The majority of South Carolina's coastal habitat sampled in 2001-2002 had B-IBI values indicative of undegraded bottom-dwelling communities. Degraded communities were observed in 3% of open water habitat and 4% of tidal creek habitat. Possible degradation of bottom-dwelling communities was founinat 14% of the open water habitat and 27% of the tidal creek habitat in the 2001-2002 survey (Figure 6).

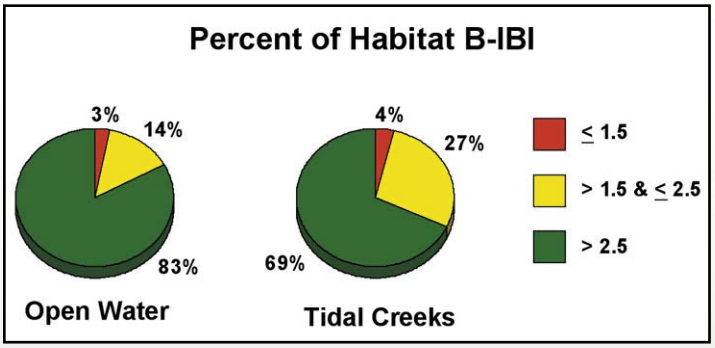


Figure 6. Estimates of the percent of the state's coastal habitat representing benthic index of biological integrity (Benthic-IBI) values that represent undegraded (> 2.5, green), marginally degraded (> 1.5 and ≤ 2.5, yellow) or degraded (≤ 1.5, red) benthic communities.

Estuarine waters support a diverse and transitory fish and crustacean assemblage, with many species often present only during certain seasons or life stages of development. The biota sampled by trawls at tidal creek and open water stations displayed a similar array of species, including many commercially and recreationally important species such as white shrimp, brown shrimp, spot, Atlantic croaker, and silver perch. The average abundance of fish and crustaceans in tidal creek habitats was nearly twice the average abundance in open water habitats, and represented a statistically significant difference. The average number of species collected per trawl in tidal creek stations (even with shorter tow lengths in tidal creeks) was slightly higher than those collected at open water sites, although these differences were not statistically significant. Differences in the finfish and crustacean communities between tidal creek and open water habitats may be explained by gear effectiveness in different habitat types, as well as by the physiological and behavioral response of different species and life stages to the physical characteristics of these habitats.

Integrated Measure of South Carolina's Estuarine Habitat Quality

A primary goal of SCECAP is to combine integrated measures of water quality, sediment quality, and biological condition into an overall measure of habitat quality at each site and for the entire coastal zone of South Carolina. Integrated measures provide a more reliable assessment than any single measure or group of measures representing only one component of the habitat. For example, poor or fair water quality based on state standards or historical data may not result in any clear evidence of impaired biotic communities. Many of the state's water quality standards are intentionally conservative to be protective, and some contravention of these conditions are not severe enough to represent impairment. Similarly, fair or poor sediment quality may not result in degraded biotic condition because the organisms are either not directly exposed to the sediments (e.g., phytoplankton, fish) or because the contaminants are not readily bioavailable to the animals. When two or more of the three measures (i.e., water quality, sediment quality, or biotic condition) are only fair or poor, there is increased certainty that the habitat may be limiting.

The integrated measure of habitat quality indicated that approximately 81% of South Carolina's open water was considered to be good in overall condition, 17% was in fair condition, and 2% was in poor condition (Figure 7). In comparison, 76% of the state's tidal creek habitat was in good condition, 24% was in fair condition, and none of the tidal creek habitat was poor in overall habitat condition. The higher percentage of tidal creek habitats that coded as

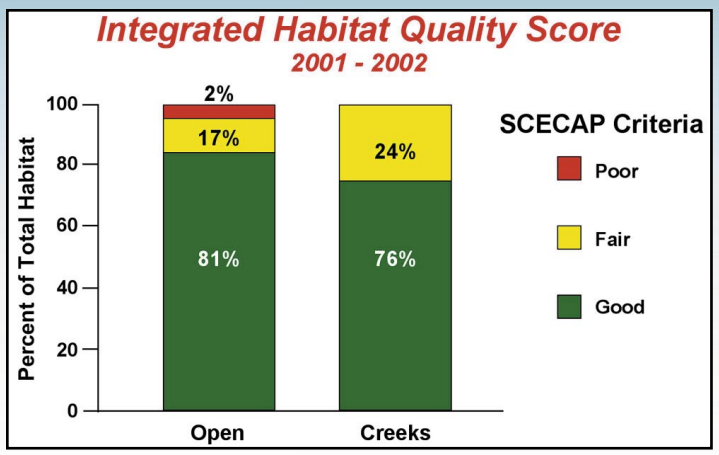


Figure 7. Estimated percentage of South Carolina's estuarine tidal creek and open water habitat that is in good, fair, or poor condition using an average of water, sediment, and biological quality scores developed for the SCECAP monitoring effort.

fair compared to open water habitats is likely due to the fact that these shallow wetland habitats are often the first areas impacted by anthropogenic stresses from upland development.

A comparison of integrated habitat quality scores from the first four years of SCECAP (1999-2002) indicates no major changes in the percentage of the state's estuarine habitat that was considered to be good, fair, and poor (Figure 8). During this time period, South Carolina has experienced an unusual drought period that would have reduced the amount of runoff from upland to wetland habitats, and undoubtedly influenced many of the individual measures collected. Conditions during years with more normal rainfall may change the overall assessment of the state's coastal condition.

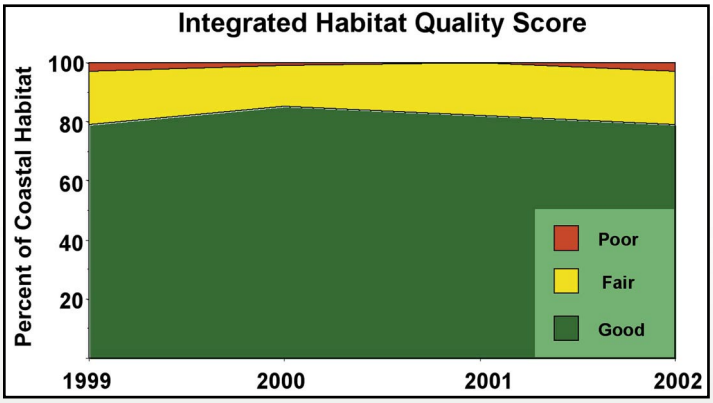


Figure 8. The proportion of South Carolina's estuarine habitat that ranks as good (green), fair (yellow) or poor (red) using the integrated habitat quality score when tidal creek and open water habitats are combined and compared on an annual basis.

The 2001-2002 array of stations is presented in Figure 9 with each station color-coded based on the overall integrated habitat quality score. Station color codes represent overall condition. In the northern portion of the state, one station coded as poor in overall quality. This site was located near dredge disposal areas, which may have contributed to the poor habitat condition. One other non-randomly located site in the Georgetown Harbor turning basin also had poor overall habitat quality. In addition, the northern portion of the state had five stations coding as fair in overall quality, and eight stations had good overall habitat quality.

Of the 36 randomly located sites sampled in the central portion of the state's coastal zone, five ranked as fair in overall quality, and the rest had good overall habitat quality (Figure 9). All except one of the fair sites were located in the Charleston Harbor estuary, with three of those sites located in proximity to industrial areas in either the Cooper or Ashley Rivers. Three of the five non-random sites sampled in this estuary (lower portion of Shem Creek, Ashley River in Brickyard Creek, and near the Columbia Nitrogen Plant) had fair or poor overall habitat quality.

In the southern portion of the state, 12 of the 66 randomly selected sites were fair in overall habitat quality, and the remaining sites had good overall habitat quality (Figure 9). None of the other sites sampled in this region had poor scores for any of the three habitat quality components. This may reflect the pattern of higher urban and industrial land use in the Winyah Bay and Charleston Harbor area relative to the southern part of the state that does not have as much urban and industrial development per total area of watershed.

The detailed information on water quality, sediment quality, and biotic condition collected during 2001-2002, in addition to previous and future SCECAP sampling efforts, provides a valuable database on the status of South Carolina's tidal creek and open water habitats. The program samples areas with no clear evidence of anthropogenic input, as well as areas near industrial and residential development. The SCECAP database also provides a valuable measure of the proportion of the state's coastal habitat that is good, fair, or poor with respect to the various measures collected. Moreover, the results obtained from SCECAP allow the quality of South Carolina's coastal habitats to be tracked over time, and permits comparison to ongoing assessments in neighboring states being conducted in partnership with the EPA's National Coastal Assessment Program.

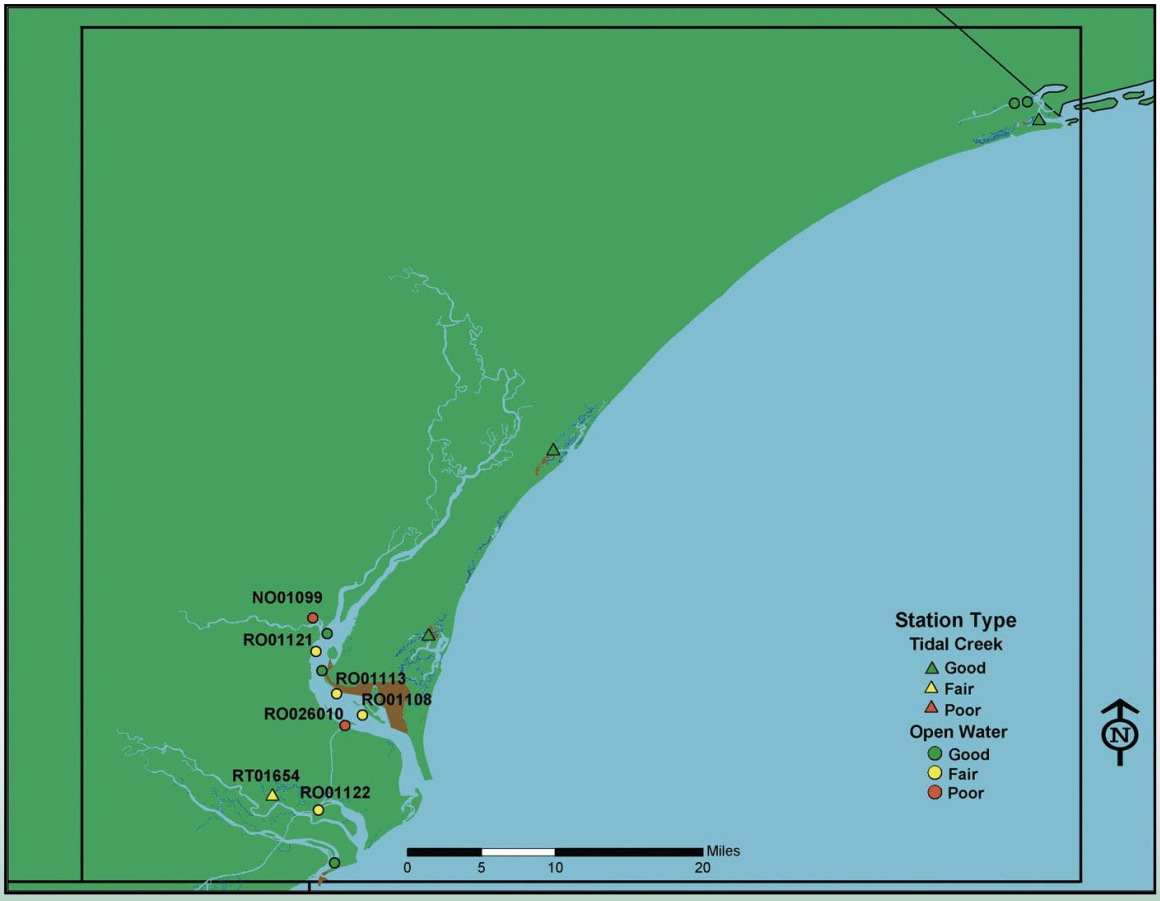
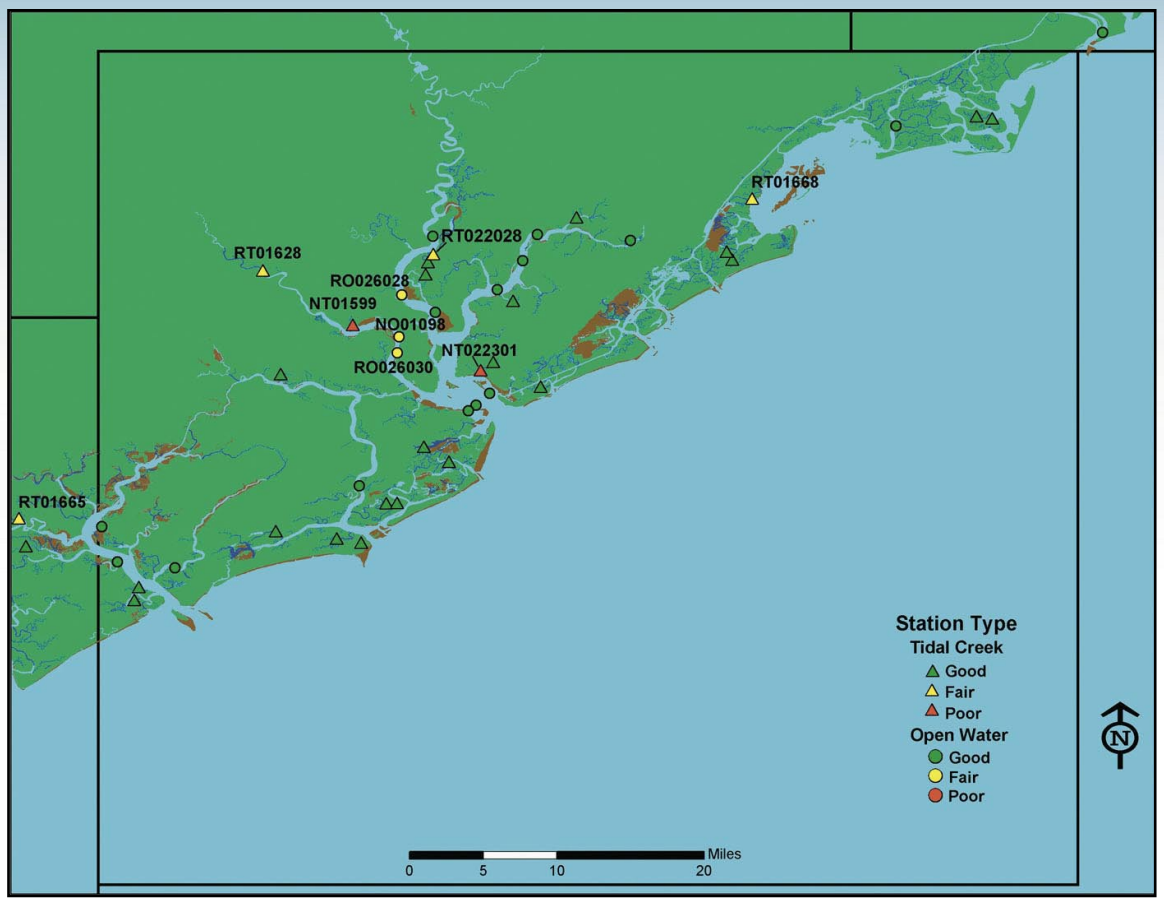


Figure 9. Distribution of open water and tidal creek stations sampled in the northern, central, and southern portions of the state during 2001-2002 that had an overall habitat quality score of good (green), fair (yellow), or poor (red) based on an integrated measure of water quality, sediment quality, and biological condition. Stations beginning with "R" represent randomly located tidal creek (T) and open water (O) locations. Stations beginning with "N" represent non-randomly located tidal creek (T) or open water (O) stations.


RT01668
RT022028
RT01628
RO026028
NT01599
NO01098
NT022301
RO026030
RT01665
Station Type
Tidal Creek
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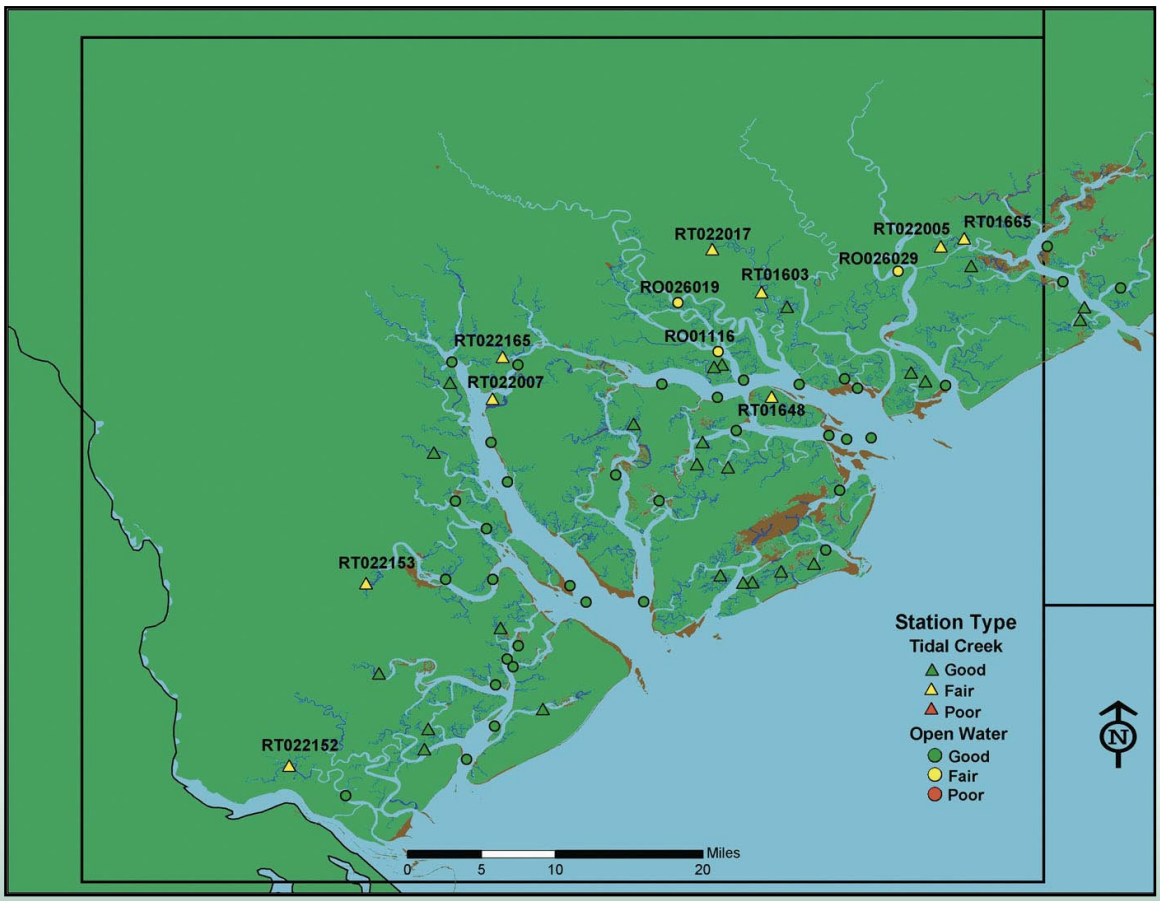
Fair
Poor
Open Water
Good
Fair
Poor
N
Miles
0
5
10
20


RT022017
RT022005
RT01665
RO026029
RT01603
RO026019
RT022165
RO01116
RT022007
RT01648
RT022153
RT022152
Station Type
Tidal Creek
Good
Fair
Poor
Open Water
Good
Fair
Poor
N
Miles
0
5
10
20

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